

Jet Propulsion Laboratory
California Institute of Technology

Radiance and Reflectance algorithms for the AVIRIS-NG India Campaign, 2015-16

David R. Thompson¹

Robert O. Green¹

Michael L. Eastwood¹

Sarah Lundeen¹

Winston Olson-Duvall¹

Amit Sen¹

Bimal K. Bhattacharya²

K. N. Babu²

A. K. Mathur²

Manish Saxena²

Joseph W. Boardman³

Joseph W. Boardman³

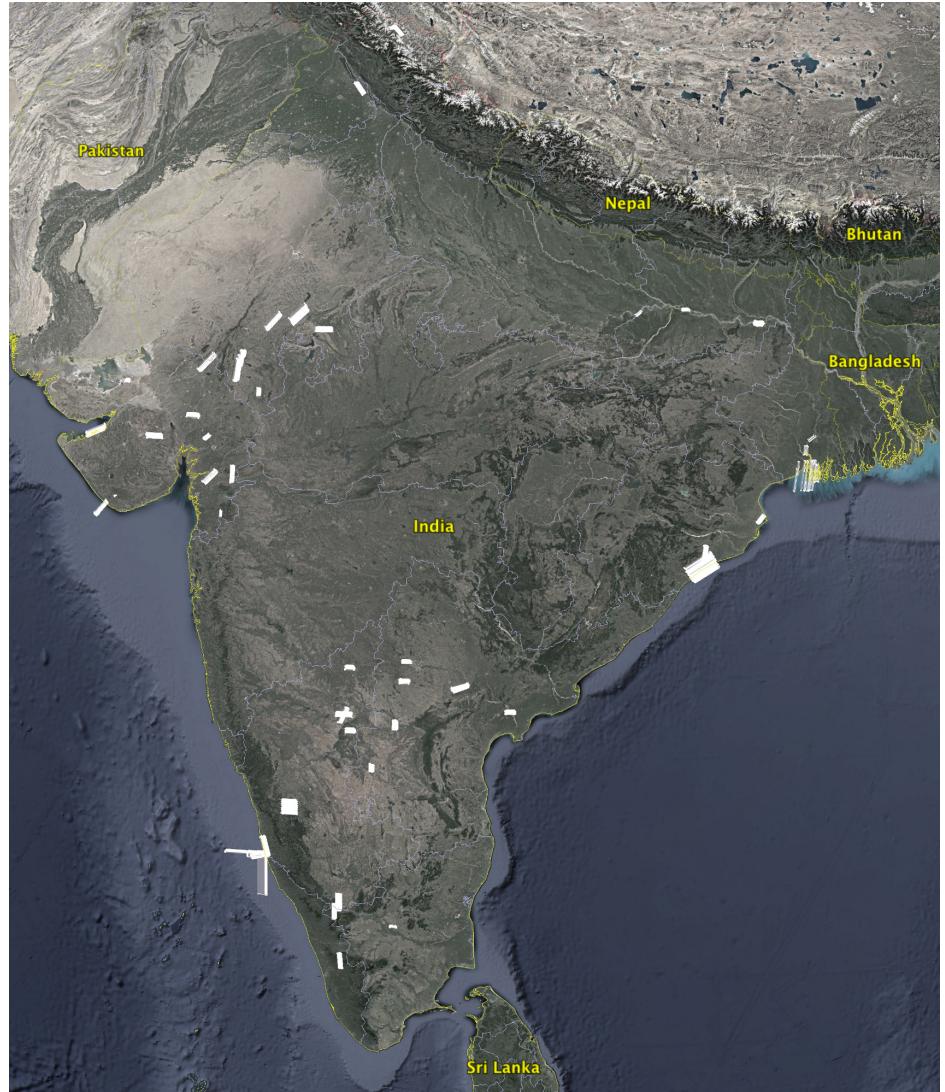
¹Jet Propulsion Laboratory, California Institute of Technology

² Indian Space Research Organization

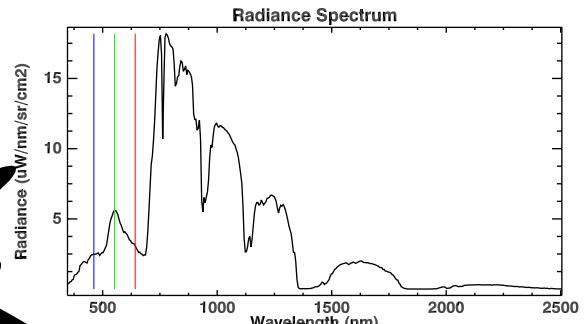
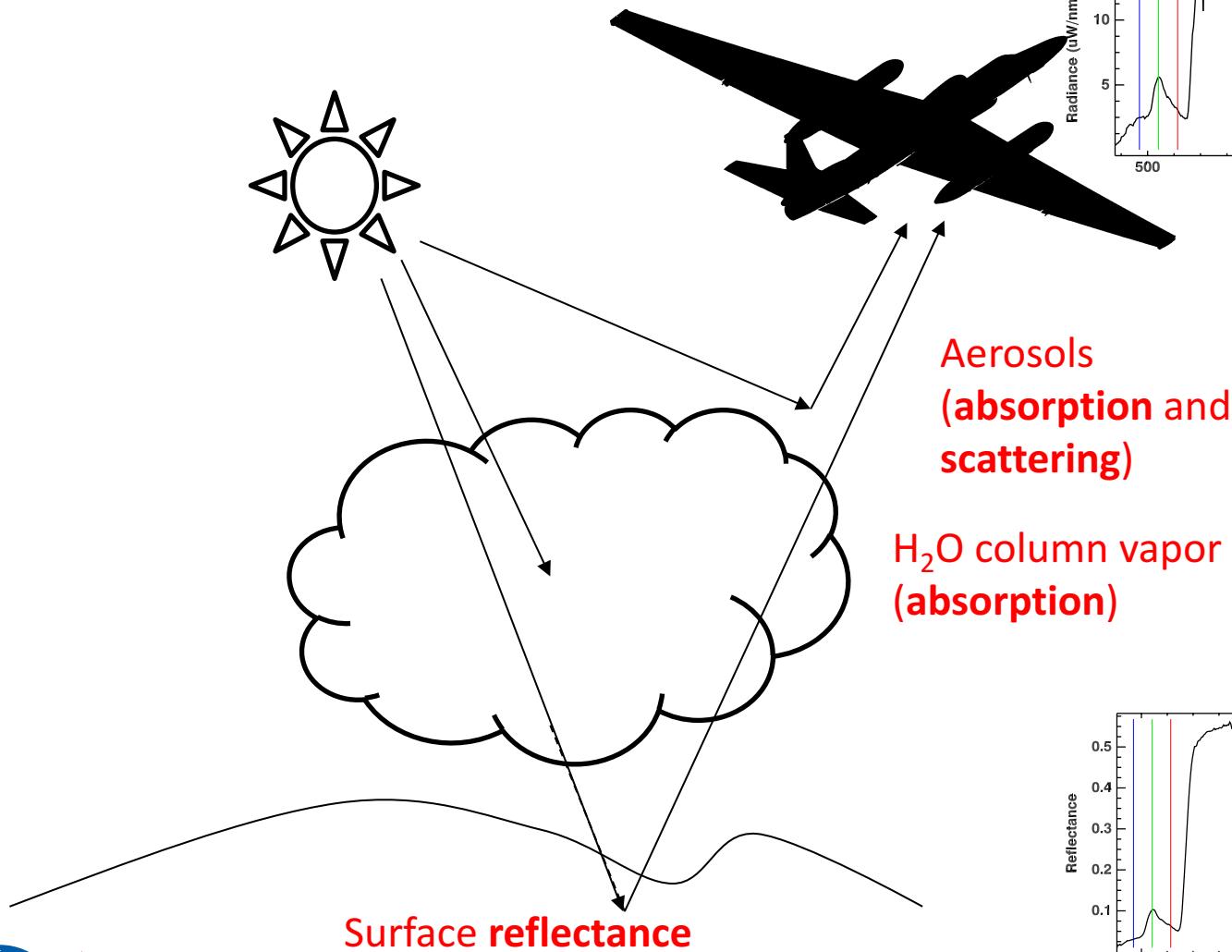
³ Analytical Imaging and Geophysics, LLC

Agenda

1. Standard products
2. Latest enhancements
3. Ongoing research

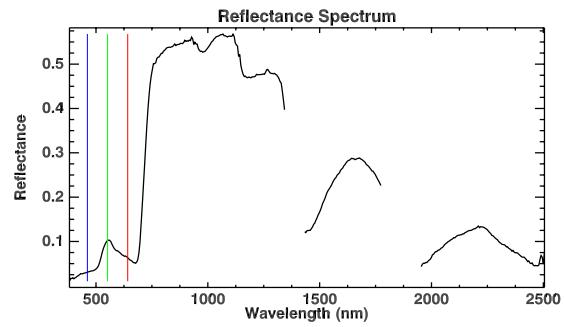


Atmospheric Correction



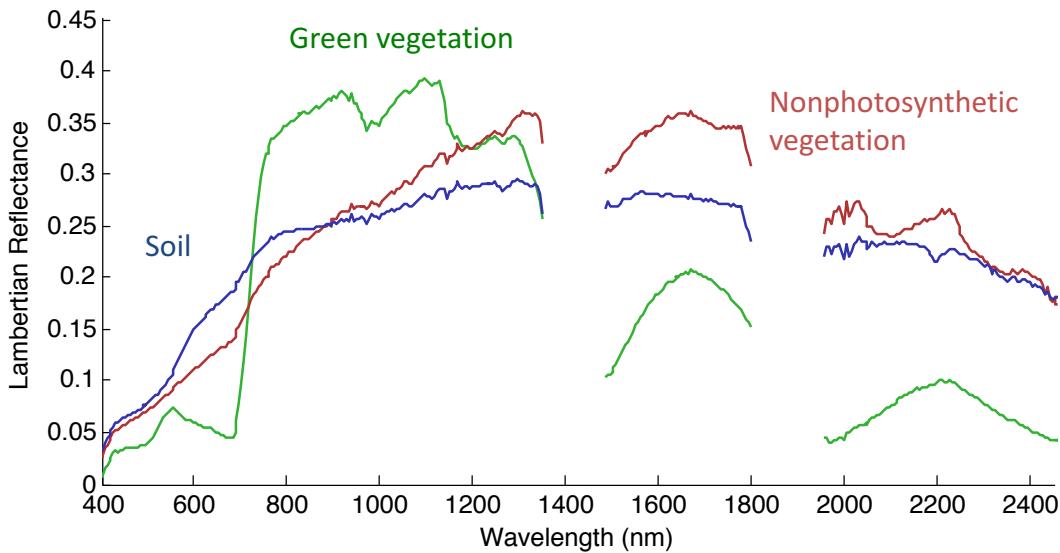
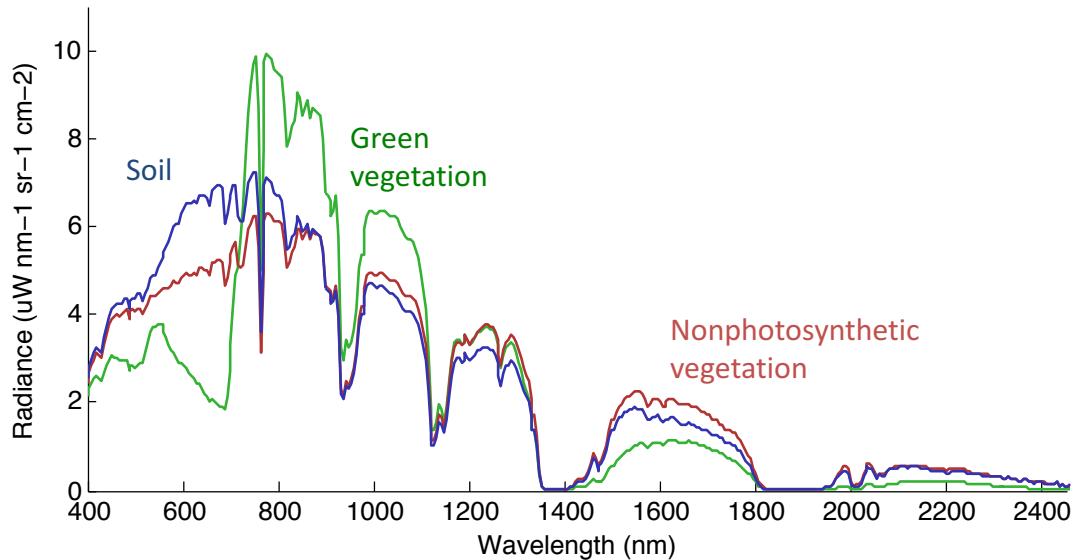
Aerosols
(absorption and
scattering)

H₂O column vapor
(absorption)

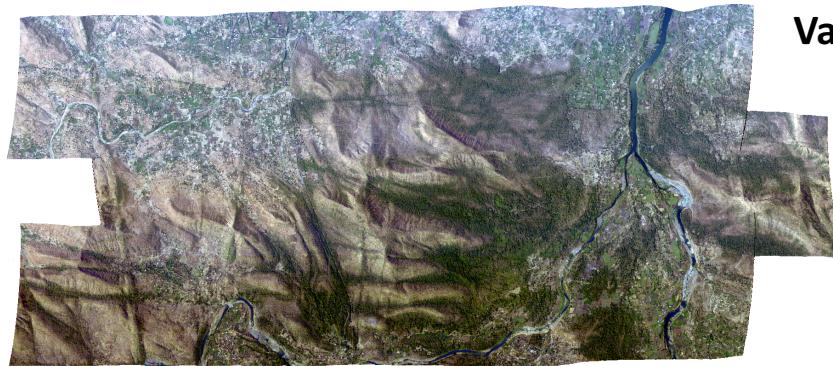


Typical India Campaign L1 & L2 spectra

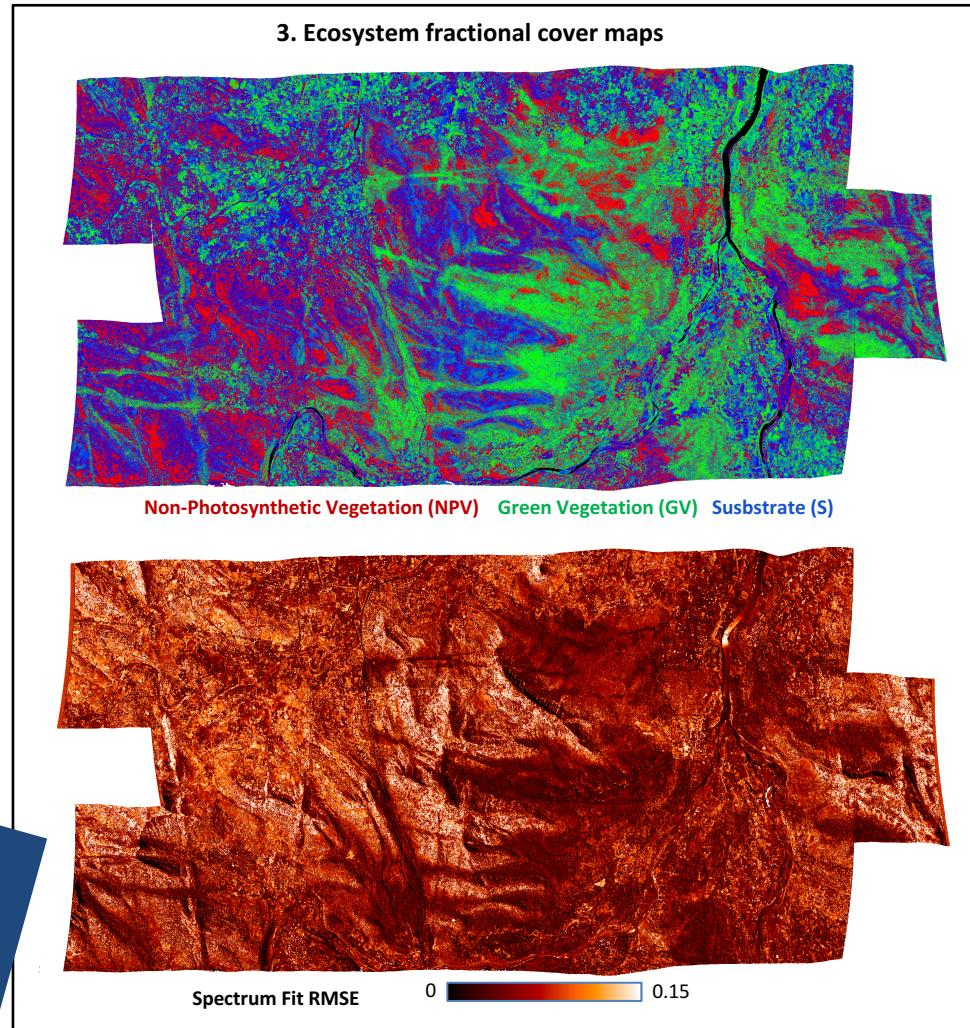
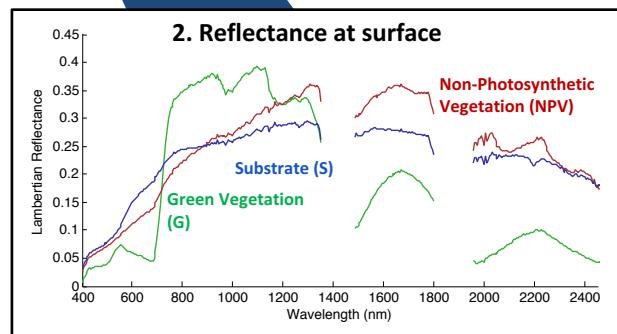
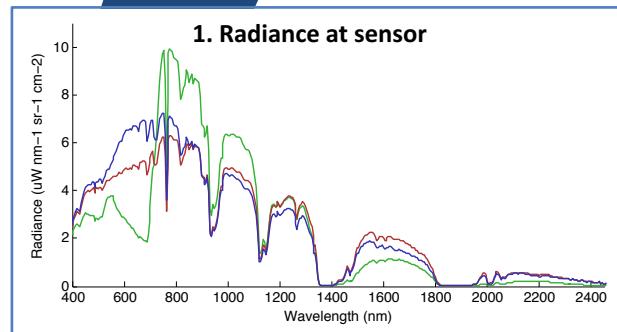
- L2 provides pressure altitude retrievals
- H_2O vapor via three-phase spectrum fits
- Heuristic aerosol correction



Level 3: Ecosystem composition



Vansda, India 9 Feb 2016

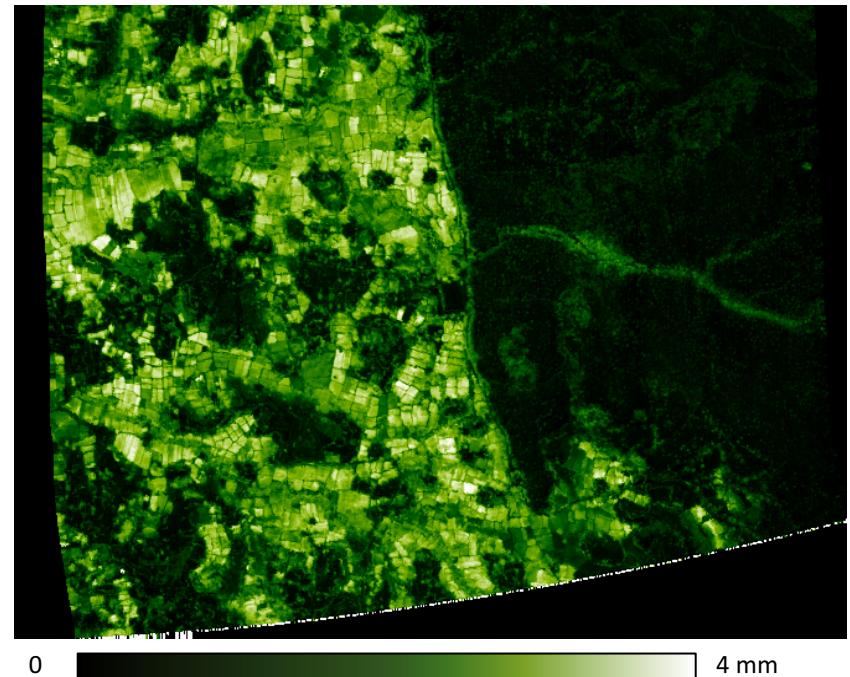


Level 3: Vegetation water absorption

ang20160203t060655



Equivalent water thickness (EWT)



7/24/17

Imaging Spectroscopy - David.R.Thompson@jpl.nasa.gov

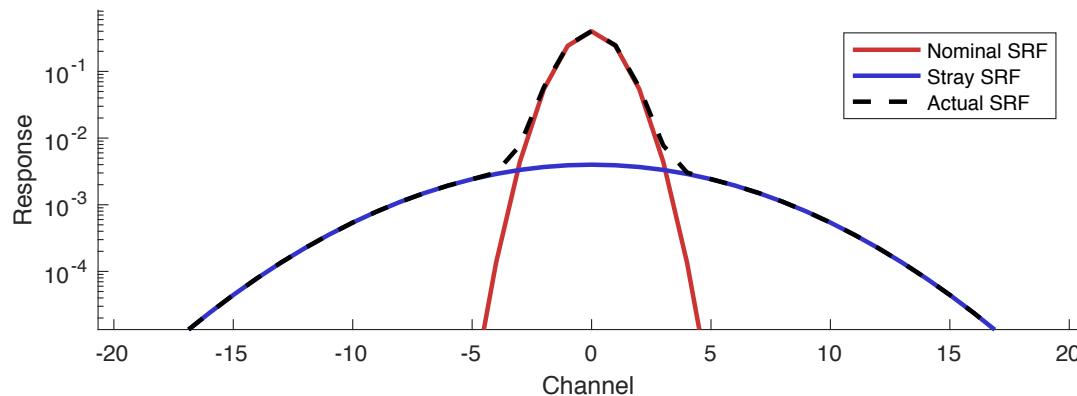
Agenda

1. Standard products
2. Latest enhancements
3. Ongoing research



Recent refinements

- Improved AVIRIS-NG radiometric solution including new calibration data
- New correction for AVIRIS-NG spatial and spectral scatter (i.e. the stray SRF)



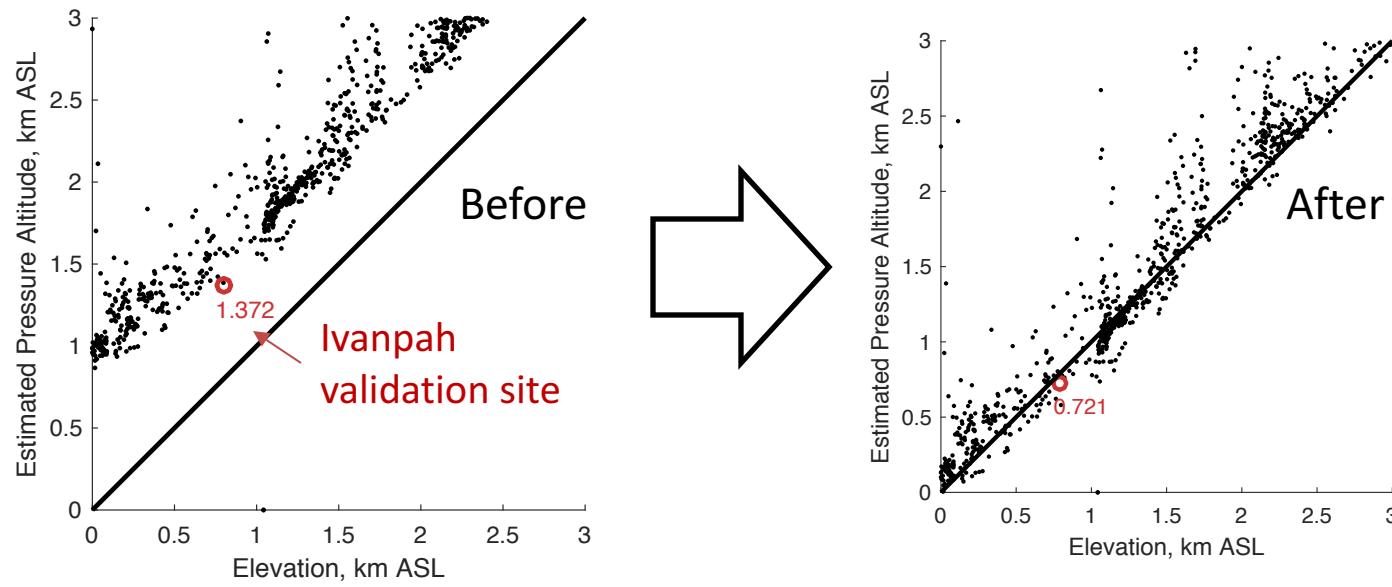
- New ecosystem composition products



Radiometry refinements: spectral response correction

[Thompson et al., Remote Sensing of Environment, submitted]

- We fit spectral response characteristics using the oxygen A band
- A simple correction solves a surface pressure retrieval bias, improving Rayleigh scattering corrections

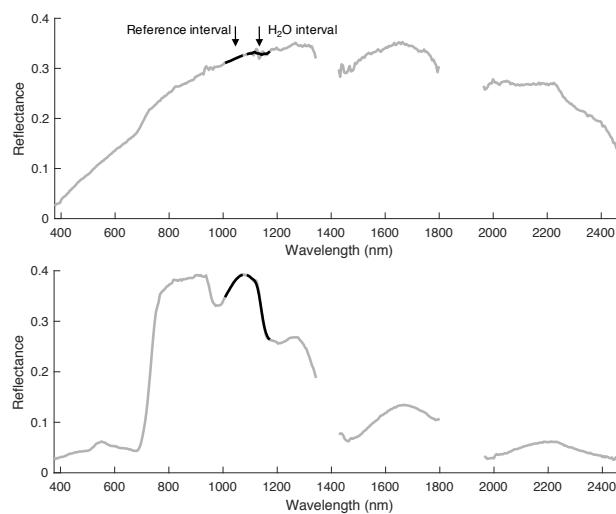


Radiometry refinements: spectral response correction (contd.)

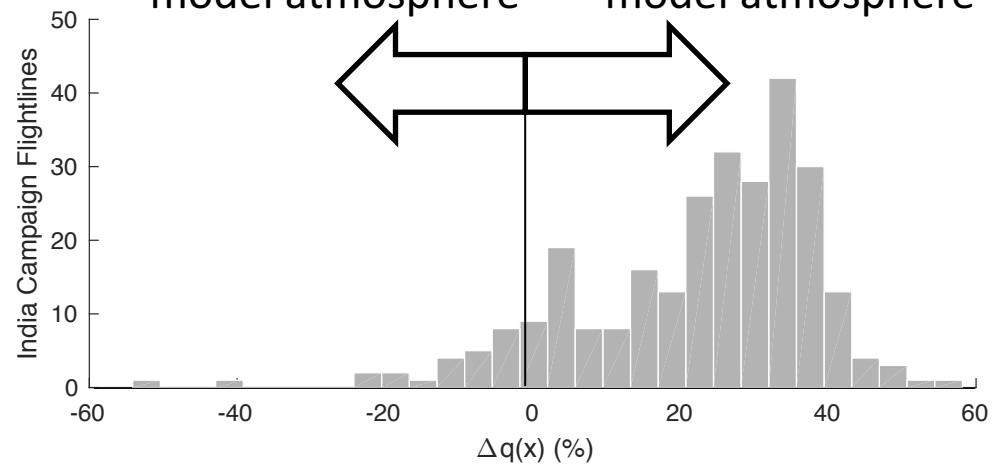
[Thompson et al., Remote Sensing of Environment, submitted]

Applying this to the entire India dataset yields significant improvement in H_2O residuals

Water vapor residual estimation



Worse match to model atmosphere Better match to model atmosphere



Agenda

1. Standard products
2. Latest enhancements
3. Ongoing research



Next steps: optimal estimation

- Joint retrieval of surface and reflectance
- Fully probabilistic formulation
- Measurement model:

$$y = F(x) + \epsilon$$

↑
measurement forward model
 (RTM) random error

- Minimize error function for covariances S :

$$\chi^2(x) = (F(x) - y)^T S_\epsilon^{-1} (F(x) - y) + (x - x_a)^T S_a^{-1} (x - x_a)$$

Model match to measurement Bayesian prior



Next steps: optimal estimation

- Can model exact absorption-in-scattering for accurate correction of H_2O vapor absorption residuals
- Permits strong coupling between surface and atmosphere to retrieve and compensate for BRDF
- Can model and retrieve additional aerosol parameters using information across the VSWIR range, improving accuracy of aerosol correction
- Enables principled introduction of ancillary measurements via the prior distribution
- Permits a rigorous analysis of VSWIR atmospheric information content via Degree of Freedom (DOF) analysis
- Reduces pushbroom striping by modeling detector-specific measurement noise S_ϵ .
- Produces rigorous posterior uncertainty estimates for use in downstream analyses.



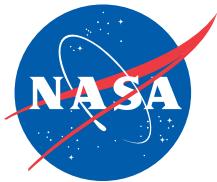
Thanks!

ISRO and meeting
organizers

NASA Earth
Science Division

The AVIRIS-NG
instrument team
and NRSC flight
campaign team





Jet Propulsion Laboratory
California Institute of Technology

Calibration and Validation for the AVIRIS-NG India Campaign, 2015-16

David R. Thompson¹

Robert O. Green¹

Michael L. Eastwood¹

Sarah Lundeen¹

Winston Olson-Duvall¹

Amit Sen¹

Bimal K. Bhattacharya²

K. N. Babu²

A. K. Mathur²

Manish Saxena²

Joseph W. Boardman³

Joseph W. Boardman³

¹Jet Propulsion Laboratory, California Institute of Technology

² Indian Space Research Organization

³ Analytical Imaging and Geophysics, LLC

Two objectives

1. Evaluate AVIRIS-NG radiometric calibration
 - Use a refined MODTRAN atmospheric model
 - Incorporate in-situ measurements of critical scene, atmospheric parameters
2. Characterize default AVIRIS-NG atmospheric correction
 - Use our current atmospheric model: 6S with decoupled scattering and gas absorption
 - Compare directly with ground reflectance measurements



Recent AVIRIS-NG radiometry enhancements

- Correct stray spectral response estimated from atmospheric calibration [Thompson et al., RSE, submitted]
- Incorporate hangar calibration data throughout the India campaign
- Recognizable by “v2” in the filename

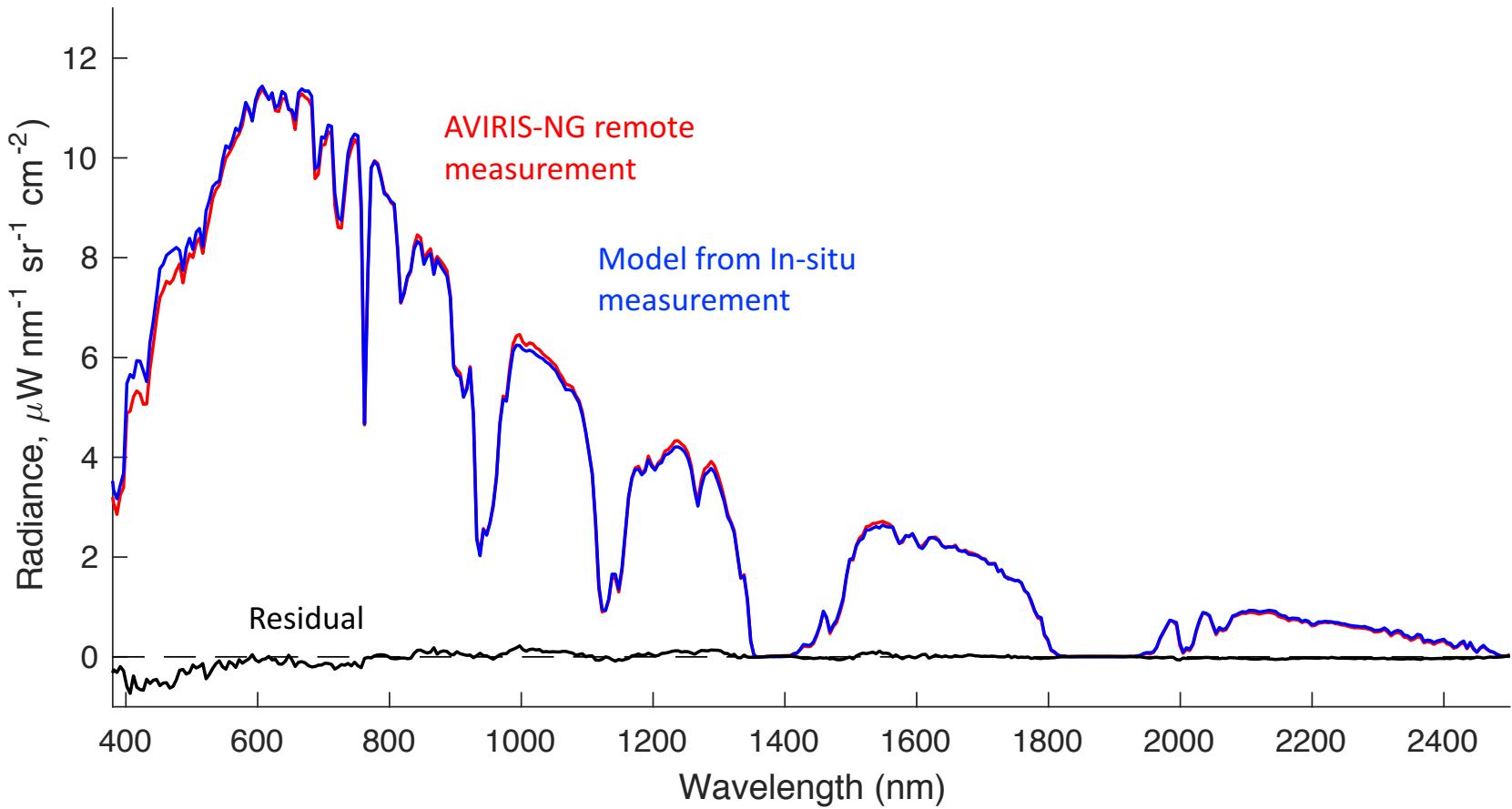


Radiative transfer models

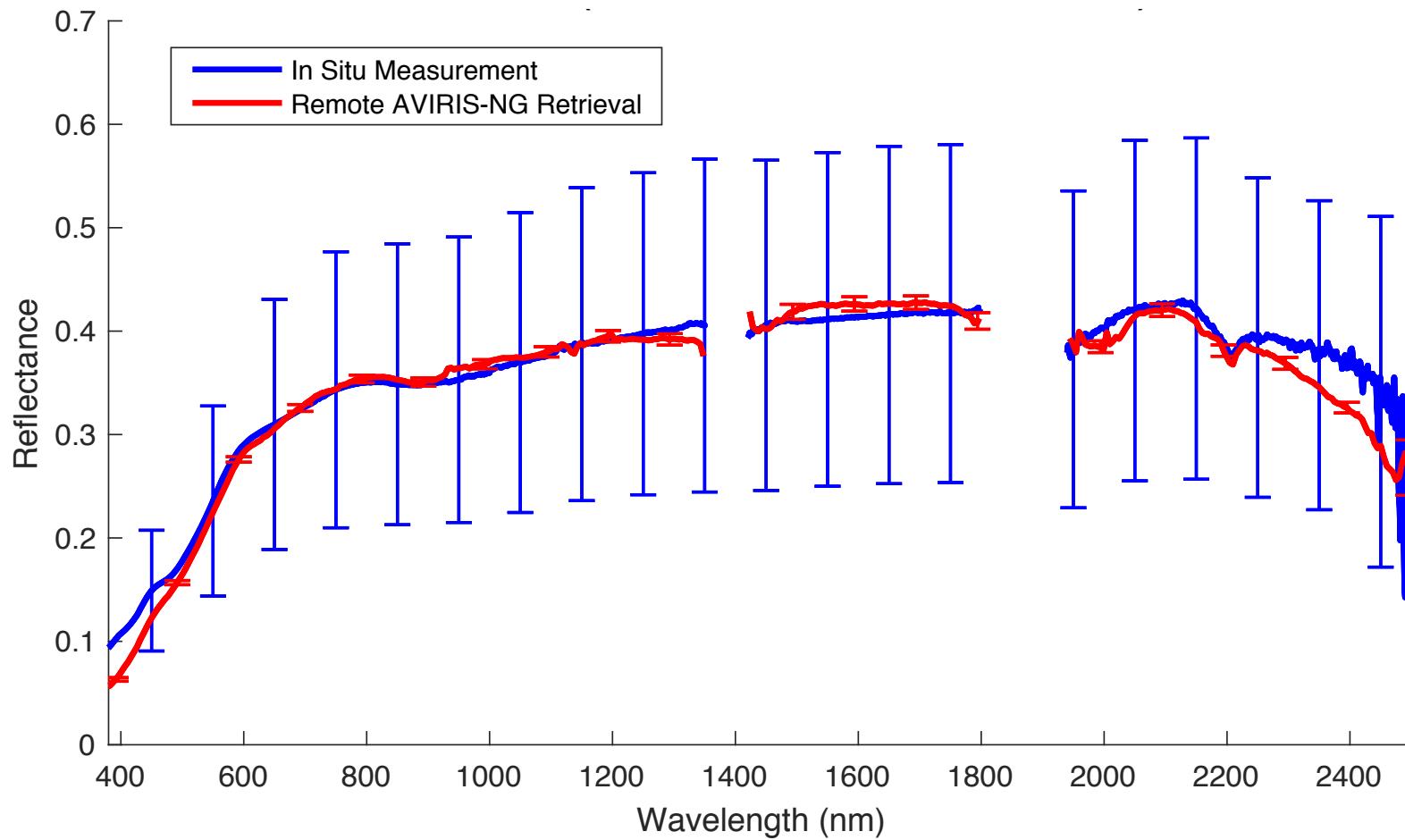
Parameter	Standard Atmospheric Correction		Custom Radiative Transfer Model	
	Value	Source	Value	Source
Radiative Transfer Model	6S	-	MODTRAN	-
Atmospheric profiles	Midlatitude Summer	Static	Tropical	Best match to spectra
Pressure altitude	189 m (standard deviation 66 m)	Retrieved [Thompson et al., 2015]	13 m	In situ data
Precipitable H₂O vapor	1.58 cm (standard deviation 0.02 cm)	Retrieved [Thompson et al., 2015]	1.1 cm	Best match to spectra, in situ data
Total Aerosol Optical Depth	0.03 (550 nm)	Retrieved [Thompson et al., 2017c]	0.3 (300 nm) to 0.1 (870 nm)	In situ data
Aerosol Single Scattering Albedo	-	-	0.5 (300 nm) to 1.0 (870 nm)	Best match to spectra, in situ
Atmospheric ozone	340 DU	Static	300 DU	Remote climatology, in situ data
Surface reflectance	Variable	Retrieved [Thompson et al., 2015]	Variable	In situ data



Radiance comparison



Reflectance comparison



Conclusions

- The AVIRIS-NG data at the Desalpar site was science quality and the instrument was well-calibrated.
- Rigorous uncertainty quantification can help achieve to the next level of precision.
- The match between remote and in situ spectra is good relative to other experiments in the literature.
- Other data from very hazy conditions could have uncertainties not revealed in these tests.
- The experiment demonstrated the ability of NASA and ISRO investigators to perform meaningful experiments together leveraging expertise and resources of both communities.

